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Title: The effect of carbohydrate mouth rinsing on multiple choice reaction time during amateur boxing.

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Authors: Daniel J. Peart[1]*, Michael Graham[2], Callum Blades[1], Ian H. Walshe[1]

1. Department of Sport, Exercise and Rehabilitation, Northumbria University, Newcastle-upon-Tyne, UK
2. Department of Exercise and Sport Science, Paramedics and Operating Department Practice, School of Health and Social Care, Teesside University, Middlesbrough, UK

*Correspondence:

Dr Daniel J. Peart, Department of Sport, Exercise and Rehabilitation, Northumbria University, Newcastle-upon-Tyne, UK, Email: Daniel.peart@northumbria.ac.uk, Tel: +44 (0)191 227 3712

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Abstract

Purpose: To examine whether the use of a carbohydrate mouth rinse (CMR) can improve multiple choice reaction time (MCRT) in amateur boxers during sparring.

Methods: Eight male amateur boxers (age 22 ± 3 years, stature 1.78 ± 0.07 m, mass 73.6 ± 14.2 kg) with at least 18 months experience in the sport volunteered. All participants attended a familiarisation session, followed by an experimental (CMR; 6% dextrose) and placebo (PLAC) trial completed in a random order. Participants undertook 3 x 2-min of sparring against an ability and size (stature and mass) matched opponent. MCRT and perceived exertion was measured before round 1, and then after each round. The respective mouth rinse was administered in a 25-ml solution for 10-s before each round. Magnitude based inferences were used to compare the results from each round (mean difference ± 90% confidence limits).

Results: The CMR was unlikely to have a beneficial effect on MCRT compared to PLAC (5 ±9.5, 4 ±3.4, -1 ±8.5 lights for each round respectively), and had a possibly harmful effect on perceived exertion in round one (10 ±20). There was an unlikely harmful effect on perceived exertion in rounds two (1 ±12) and three (9 ±23).

Conclusions: There is no evidence to support the use of CMR during sparring in amateur boxers.

Key words: Cognitive, combat, nutrition, perceived exertion, ergogenic aid

Introduction

The concept of holding an ergogenic aid in the buccal cavity for a short period of time without swallowing, also known as mouth rinsing, was first described by Carter et al. [1]. In this study cyclists used a carbohydrate mouth rinse (CMR) at regular intervals during a time trial, resulting in improved performance compared to a placebo rinse. The mechanism of action is unlikely to be metabolic as the carbohydrate is not ingested, but rather due to stimulation of the central nervous system. This idea is supported by data from Chambers et al [2] who identified that a CMR can activate areas of the brain associated with reward and regulation of motor activity. A recent review identified that this method can improve time trial performance by approximately 2-3%, but shorter anaerobic exercises may not benefit by as much [3]. Gam et al. [4] has criticised some of the research in this area for comparing an experimental mouth rinse only to a placebo. They observed that whilst the presence of carbohydrate afforded an ergogenic benefit compared to a sweetened placebo, there were no improvements compared to a non-rinse control. The act of rinsing itself may have a negative effect on performance by interrupting the athlete or affecting their breathing. Nevertheless, the presence of carbohydrate appears to have masked this possible negative effect on performance, therefore implementing the practice into a sport where the act of rinsing will not hinder their performance could be of benefit.

Combat sports typically consist of a set number of rounds interspersed by short rest periods. Such periods may offer an opportunity for athletes to perform a mouth rinse without hindering their performance during active rounds. These sports would also arguably benefit from an attenuation in cognitive as well as physical decline due to fatigue, in order to beat an opponent [5]. Rinsing the mouth with a carbohydrate solution has been shown to enhance reaction time (RT) at rest (Sanders et al, 2012), improve temporal performance during exercise [6], reduce exercise induced declines in cognitive function [7], and reduce perception of fatigue in latter stages of exercise [6]. This could be a result of an inhibition in stress hormone release [7], a moderation of self-control [8], or an increase in brain activity in areas associated with attention [2,6]. Therefore, whilst the evidence for carbohydrate mouth rinsing benefitting short term exercise is limited to a small number of recent articles investigating isolated anaerobic tasks such as vertical jumping and resistance exercises [9,10], the potential benefits for cognition warrants research into its applicability for combat sports.

The purpose of this study was to investigate the effects of a CMR on multiple choice reaction time (MCRT) in amateur boxers.

Method

Participants

Eight male amateur boxers (age 22 ± 3 years, stature 1.78 ± 0.07 m, mass 73.6 ± 14.2 kg) with at least 18 months experience in the sport volunteered to take part in the study. All participants were in preparation for an upcoming competitive bout, with visits taking place in three consecutive weeks that were four, three and two weeks out from competition. The institutional ethics committee approved all experimental procedures, and all participants provided written informed consent. Prior to sparring, all participants had completed a full medical according to England Boxing regulations

Experimental Design

Participants completed three visits to their regular training facility following a four hour fast. Visit one acted as a full familiarisation to the protocol, and visits two and three were the experimental and placebo trials completed in a randomised order. During each visit, participants completed an individual, standardised 15-min warm up, followed by 3 x 2-min rounds of sparring against an opponent, under the supervision of an England Boxing level two coach. The boxers were paired based on being within two competitive bouts of each other and within the same weight division recognized by England Boxing. The MCRT test took place before round one, and in the rest periods between each round. Participants conducted a mouth rinse immediately after each MCRT, and rated their perception of overall exertion using the CentiMax scale (CR100) [11]. Both fighters in each bout received the same condition.

Mouth Rinse

Participants rinsed their mouth for 10-s each time with 25 ml of a carbohydrate solution (CMR) (6% dextrose), placebo (0.5% artificial sweetener, Tesco UK), or water (familiarisation).

Multiple Choice Reaction Time (MCRT)

The MCRT was programmed using an automated reaction light system (Witty System, Microgate, Italy), arranged as a four light system with the order of lights set to random. Participants had to react to each light by tapping the surface, which subsequently triggered the next light to appear. The aim was to tap and turn off as many lights as possible during a 40-s period. The lights were arranged in a diamond shape, with the highest sensor 170 cm from the floor, and another 39.5 cm lower on the same vertical line. Two remaining lights were on a horizontal line 18.5 cm lower than the top sensor, 21 cm either side of the vertical line. These placements were used to match the approximate height of head and body shots, and to be approximately shoulder width apart. Pilot work with five participants resulted in a coefficient of variance of 3% over three visits, with a minimal worthwhile change of seven lights between rounds (one more than the upper 95% confidence interval of the typical error).

Data Analysis

Differences (mean ± 90% Confidence Limits) between visits for each round were quantified using magnitude based inferences (MBI). Reproducibility data from pilot work identified that six people would be suitable to detect a difference of seven lights between rounds with 80% power, based on within and between subject standard deviations of 6 and 10 respectively. Both the MBI analysis and sample size estimation were completed using custom-made spreadsheets (Will Hopkins; www.sportsci.org). The percent chances of an effect being beneficial, trivial or harmful was interpreted using the following qualitative terms; <0.5%, most unlikely or almost certainly not; 0.5 to 5%, very unlikely; 5 to 25%, unlikely or probably not; 25 to 75%, possibly; 75 to 95%, likely or probably; 95 to 99.5%, very likely; >99.5%, most likely or almost certainly [12].

The reproducibility of the MCRT was examined using the pre-bout scores in visits two and three in order to make the meaningful change specific to our sample. This resulted in a meaningful change for number of lights tapped to be eight, and the average RT between lights to be 0.16 seconds. The meaningful change for RPE was set as a 38.6% change from the placebo result, according to reproducibility data from Scott et al. [13]. This equated to 10 for round one, 14 for round two, and 17 for round three.

Results

Mean and standard deviation for each variable in each round is available in Table 1, and the group comparisons and inferences are in Table 2. There were no clear differences between groups for any of the variables, apart from a possibly harmful effect of CMR on RPE in round one.

Discussion

The purpose of this study was to examine if the addition of carbohydrate to a mouth rinse used between rounds could improve MCRT in amateur boxers. The main findings were that a CMR had no effect on MCRT or perceived exertion.

Carbohydrate ingestion has been shown to improve reaction time during exercise [14,15], possibly by delaying the onset of fatigue. Similarly, previous work has shown that carbohydrate does not necessarily need to be ingested, as a CMR can also improve cognitive function during exercise [7]. However, we are unable to concur, as there were no clear differences between conditions in the present study. This may be because there was no apparent change in RT through the rounds, whereas Konishi et al. [7] saw an exercise induced reduction in RT in their study using 65-min of running. Moriarty et al. [16] followed a number of amateur boxers through one to three bouts over seven days, and observed that RT pre-bout only changed if a concussion was evident. Our findings add to this, exhibiting that RT is stable across three rounds in amateur boxers. Therefore, the exercise stimulus may not have been strong enough to identify a difference between groups. However, CMR has been shown to improve RT at rest, possibly by enhancing motivation via stimulation of the anterior cingulate cortex and the striatum [8]. This means that an exercise-induced decrement in RT should not have been necessary to see an ergogenic effect. It may be that the participants in this study were already operating at an optimal level of arousal and motivation due to the competitive nature of the exercise task. Conversely, other authors have also reported no positive effects of a carbohydrate mouth rinse on RT [17], suggesting that an ergogenic effect is not guaranteed.

Previous work examining the effects of CMR on RPE during exercise has reported either no change or a benefit [6], with no studies observing a harmful effect. In the current study, perceived exertion was marginally higher under the CMR condition in each round, and the intervention had a possibly harmful effect in round one. Scrutiny of the results identifies that this difference is mainly the result of one participant who reported a 57-point difference between conditions. It is not clear why this is the case, but it is a risk associated with using subjective measurements to quantify workload in combat sports [18]. A particular event such as a late punch may have influenced participants' perceived exertion in this study. The absence of an objective measure to accompany perceived exertion is a limitation of the current study, as is the absence of session RPE [19].

The current study benefits from a number of factors that enhance its ecological validity, such as the fact that trained amateur boxers performed a familiar translatable task in a familiar environment. Furthermore, each fighter was in preparation for an upcoming competition.

However, by the nature of increasing ecological validity, there are some limitations we must acknowledge. Firstly the open nature of the exercise task meant that workload could not be controlled and therefore it cannot be discounted that workload may have been different between visits. An objective measurement of workload such as heart rate alongside perceived exertion could have provided more insight, but this was not possible for logistical reasons. We attempted to minimise the difference between conditions by pairing each participant with somebody that they had experience sparring against, and taking advice from the coach to ensure that participants were matched for size (mass and stature), experience and ability. Secondly, previous authors have suggested that mouth rinsing may have negative implications for performance as it interrupts an athlete's action and breathing [4]. Boxing was selected as the sport in this study due to the natural rest points between rounds, so minimising any possible negative effect of mouth rinsing identified in studies comparing placebo to a control [4]. However, boxing is a sport in which it is difficult to quantify performance. Siegler and Hirscher [20] attempted to measure performance by scoring rounds during a competitive fight, however the score may be influenced as much by the opponent as the fighter being observed. RT was included as the outcome in this study as; (i) it could be measured in a closed environment without interference from the opponent, (ii) making fast motor actions under time pressure is an integral aspect of combat sports [5], and (iii) others have improved RT using a CMR intervention [7,8].

Practical Application

Our findings provide no evidence to support the use of a CMR during a sparring session that replicates a 3 x 2-min round bout, but it is unknown whether a CMR may be beneficial during longer training sessions, or during periods of progressive weight loss in preparation for competition. The MCRT used in this study had high repeatability, and the absence of a change in RT within a bout adds to previous literature showing no change between bouts unless a concussion is evident [16], so future research could look at using RT as a tool for coaches to screen their athletes.

Conclusion

In conclusion, there is no evidence that the use of a CMR in between rounds improves MCRT.

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Table 1 Reaction time and perceived exertion in each round (mean ± SD)

	Round 1	Round 2	Round 3
Reaction time (no. lights)			
PLAC	72 ± 11	74 ± 9	77 ± 10
CMR	77 ± 6	78 ± 7	77 ± 8
Reaction time (s)			
PLAC	0.55 ± 0.12	0.54 ± 0.04	0.55 ± 0.06
CMR	0.52 ± 0.05	0.53 ± 0.09	0.52 ± 0.05
Perceived exertion (CR100)			
PLAC	26 ± 17	36 ± 19	45 ± 26
CMR	36 ± 26	37 ± 22	54 ± 25

Table 2. Magnitude based inferences of differences between conditions

Variable	Comparison	Difference between groups (% mean; 90%CL)	Likelihood (%) of intervention being beneficial / trivial / harmful	Clinical inference
Reaction time (no. lights)	R1 CMR to PLAC	5 ±9.5	28.3 / 69.9 / 4.3	Unclear
	R2 CMR to PLAC	4 ±3.4	3.0 / 97.0 / 0.0	Very unlikely beneficial, most unlikely harmful
	R3 CMR to PLAC	-1 ±8.5	4.2 / 87.6 / 8.1	Unlikely harmful, very unlikely beneficial
Reaction time (s)	R1 CMR to PLAC	-0.03 ±0.12	3.5 / 95.6 / 0.9	Very unlikely harmful, very unlikely beneficial
	R2 CMR to PLAC	-0.01 ±0.16	5.1 / 91.2 / 3.6	Very unlikely harmful, unlikely beneficial
	R3 CMR to PLAC	-0.03 ±0.06	0.2 / 99.8 / 0.0	Most unlikely harmful, most unlikely beneficial
RPE	R1 CMR to PLAC	10 ±20	1.4 / 48.6 / 50.0	Possibly harmful, unlikely beneficial
	R2 CMR to PLAC	1 ±12	0.0 / 100.0 / 0.0	Most unlikely harmful, most unlikely beneficial
	R3 CMR to PLAC	9 ±23	0.3 / 85.6 / 14.0	Unlikely harmful, most unlikely beneficial